Office of Environment, Safety and Health • U.S. Department of Energy • Washington, DC 20585

OPERATING EXPERIENCE SUMMARY

Office of Environment, Safety and Health

Summary 2001-09

The Environment, Safety and Health (EH) Office of Performance Assessment and Analysis publishes the Operating Experience Summary to promote safety throughout the Department of Energy (DOE) complex by encouraging the exchange of lessons-learned information among DOE facilities.

To issue the Summary in a timely manner, EH relies on preliminary information such as daily operations reports, notification reports, and, time permitting, conversations with cognizant facility or DOE field office staff. If you have additional pertinent information or identify inaccurate statements in the Summary, please bring this to the attention of Frank Russo, 301-903-1845, or Internet address Frank.Russo@eh.doe.gov, so we may issue a correction.

The OE Summary can be used as a DOE-wide information source as described in Section 5.1.2, DOE-STD-7501-99, *The DOE Corporate Lessons Learned Program*. Readers are cautioned that review of the Summary should not be a substitute for a thorough review of the interim and final occurrence reports.

Operating Experience Summary 2001-09

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EVENTS

DEGRADED RETAINING HOOKS ON DRUM DOLLIES

On October 25, 2001 at the Rocky Flats Environmental Technology Site, a retaining drum hook on a drum dolly broke, causing the drum to fall to the floor in Building 371. The drum was not breached, and no personnel were injured. The dolly is a Harper Model 9468 with a rated capacity of 1,000 pounds. The 55-gallon drum weighed 385 pounds. An inspection of 33 other dollies found 21 with inadequate retaining hook welds, along with hooks that have a larger than normal opening. Further information will be made available in a later report. (ORPS Report RFO--KHLL-371OPS-2001-0080)

1. CHEMIST BURNED BY SODIUM HYDROXIDE FROM RUPTURED FLASK

On September 14, 2001, in a laboratory in Building 4500N at the Oak Ridge National Laboratory (ORNL), a capped polymer flask containing hot concentrated sodium hydroxide ruptured (Figure 1). The highly caustic solution sprayed onto a chemist, severely burning him. The chemist had not been wearing a lab coat, gloves, or goggles, as suggested by laboratory guidance. (ORPS Report ORO--ORNL-X10NUCLEAR-2001-0029)

Figure 1. Ruptured flask

The chemist was working alone, performing a routine activity that had been done hundreds of times before, mixing reagents in a Nalgene flask in preparation for a controlled experiment. He knew that the sodium hydroxide solution he created was exothermic and that the flask should have been left open, but in this incident he capped the flask by mistake. The build-up of heat and pressure in the flask caused it to suddenly rupture and spray caustic solution on the chemist and parts of the laboratory. The chemist immediately rinsed himself in an eyewash/shower in the outside hallway, but later was found to have first, second, and third degree burns to his hands, face, and torso. Burns to one eye were the most serious of his injuries. An emergency crew transported him to a hospital, where he was treated and stayed two days to recover. Full recovery of his vision remains questionable.

Had the chemist been wearing goggles, gloves, and a laboratory coat, his injuries would have been far less severe. Laboratory guidance suggested that such personal protective equipment (PPE) be used, but there was no strict procedural requirement to do so. The contractor has yet to release the results of its investigation and recommend corrective actions; however, its preliminary lessons learned emphasize the need to wear PPE suitable for the task performed and to warn against complacency when doing repetitive hazardous work.

A search of ORPS reports found several other accidents at DOE laboratories during recent years, including two involving injuries from flasks and glassware. On July 20, 2000, a glass flask ruptured at the Idaho National Engineering and Environmental Laboratory, causing wounds and bruises to a laboratory worker. (ORPS Report ID--BBWI-TOWN-2000-0004). On May 20, 2001, a graduate student at the Lawrence Berkeley National Laboratory broke two pieces of laboratory glassware while attempting to separate them, and received a cut on the hand that later became infected and required hospital treatment. Had the student worn heavy gloves, the cut could have been avoided. (ORPS Report OAK--LBL-CSD-2001-0002)

These occurrences illustrate the importance of wearing PPE appropriate for laboratory hazards, and being vigilant of such hazards, even while performing routine activities.

KEYWORDS: *Chemical burn, caustic solution, laboratory, flask, personal protective equipment*

ISM CORE FUNCTION: *Develop and Implement Hazards Controls*

2. PRECAUTIONARY SHUTDOWN OF STEAM DISTRIBUTION SYSTEM PREVENTS WATER HAMMER

On October 13, 2001, at Argonne National Laboratory–East (ANL-E), the boilerhouse engineer noticed erratic pressure fluctuations in the steam lines from the boilerhouse to the site steam distribution system. A manhole serving as the transition point between the aboveground and underground steam piping distribution system was filling with water, submerging the steam and condensate return lines. The steam distribution system was shut down as a precautionary measure. This action eliminated the potential for a water hammer that could have caused personnel injuries and extensive equipment damage. There were no injuries from this event. (ORPS Report CH-AA-ANLE-ANLEPFS-2001-0020)

During the afternoon and evening of Saturday, October 13, the ANL-E site experienced heavy rainfall of several inches in a relatively short period of time. At 10:45 PM, the boilerhouse engineer noticed erratic pressure fluctuations in the steam lines from the boilerhouse to the site steam distribution system. The Off-Shift Foreman investigated the situation and found water filling manhole 2, located at Inner Circle and East Gate Roads (east of Building 201). The manhole serves as the transition point between the aboveground and underground steam piping distribution system that serves the buildings in the 200 Area. The Plant Facilities and Services Utility System management and workforce were notified and responded to the site. Because the accumulating water had submerged the steam and condensate return lines in the manhole, the steam distribution system was shut down as a precautionary measure.

The prompt actions taken to secure the steam distribution system prevented the possibility of personnel injury and extensive equipment damage that could have resulted from water hammer phenomena. Water hammer, also known as steam hammer, is a pressure or momentum transient in a closed system caused by a rapid change in fluid velocity. Rapid condensation of steam by subcooled water can produce condensate-induced water hammer. Condensate-induced water hammer causes the most severe water hammer accidents, and has resulted in three fatalities at DOE facilities. A water hammer event could have taken the steam plant out of operation. The plant is critical because it provides heating, ventilation, and air conditioning (HVAC) and hot water to most of the site. In addition, repairs to equipment could have taken months to complete, and the approaching cold weather could have interrupted some site operations.

This occurrence illustrates the importance of recognizing potentially hazardous situations and taking immediate action to implement hazard controls.

Information regarding the causes and hazards of water hammer, as well as recommendations based on lessons learned from investigations of water hammer events can be found in DOE/EH-0560, Safety Notice 98-02, *Water Hammer*.

KEYWORDS: *Steam distribution system, erratic pressure fluctuations, water hammer*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls*

3. UNAUTHORIZED GAS VENTING RESULTS IN BUILDING EVACUATION

On October 10, 2001, at the Rocky Flats Environmental Technology Site, a chemist vented noxious gas (1,3-butadiene) into the ventilation system of Building 776/777, resulting in a controlled evacuation of the building. Asbestos workers had reported chemical odors on the first and second floors of the building. One of the workers felt nauseous, initiating a call for the Building Emergency Support Team. Following their response, a team member also became nauseated, requiring him and four asbestos workers to be evaluated by Occupational Medicine personnel. The chemist was assigned to clean out a laboratory within the building but was not authorized to dispose of any gases. The laboratory activities were suspended pending further parallel investigations being conducted by the DOE Rocky Flats Field Office and the contractor. (ORPS Report RFO--KHLL-SOLIDWST-2001-0060)

A chemist who worked in a laboratory in another building was tasked with cleaning out and salvaging equipment from a Mass Spectrometer Laboratory located within the Building 776/777 closure project, a former plutonium fabrication and assembly facility. During this cleanout work, the chemist found some lecture bottles that contained various chemical gases. He decided to dispose of these laboratory gases. Because of the closure project, the fume hoods in the laboratory were secured so the chemist decided to vent the gases into the building ventilation system. He assumed that the ventilation system was lined up to vent outside of the building. However, the mode of the ventilation system was set to recirculation, resulting in the vented air and gases being reintroduced into the building. Some of the bottles contained oxygen, nitrogen, and argon, but one of the bottles contained 1,3-butadiene. This gas has a gasoline-like odor, is flammable, may form explosive peroxides upon exposure to air, and is a potential occupational carcinogen.

During a fact-finding meeting, it was learned that the chemist had left the bottle of 1,3-butadiene venting unattended when he left the facility. It was also learned that the chemist did not have permission to dispose of gases or chemicals, no job hazard analysis had been performed for the evolution, and no one within the building knew he was venting chemical gases into the ventilation system.

On October 9, 2001, the Grand Junction Projects Office reported another recent occurrence caused by unauthorized work. Two contractor workers at the Pinellas Star Center were instructed to clean out a shed that had been used for a pilot bio-remediation project. The shed contained supplies for ongoing periodic sampling at the site. The workers decided to remove what they believed was abandoned conduit and piping mounted to the wall of the shed. During this activity, one of the workers partially severed an energized 110-volt electrical line while cutting conduit with a saw. The worker was not injured and did not receive an electrical shock. The workers were tasked to perform a general cleanup of the shed and were not authorized to remove electrical conduit. (ORPS Report ALO--MCTC-GJPOTAR-2001-0004)

In both of these events, personnel decided on their own to expand the scope of the work beyond what they were originally authorized to do. Even their supervisors were unaware of what they were doing. It is important for personnel who are involved with facility closures or cleanout activities to contact their supervisor or facility management for guidance and instructions if they find items that could be hazardous in nature. If the item or activity is determined to be hazardous then appropriate barriers need to be in place to protect the workers. These barriers can be physical, procedural, administrative, or based on human action. In these two events the human action barrier failed when the workers went beyond the authorization of the assigned work, transforming a normally safe evolution into a situation that threatened worker health and safety.

These events underscore the need for workers to follow the work plan, be accountable, and consider the consequences of performing unauthorized work. Working outside the approved work scope places personnel, the environment, and equipment at risk. Supervisors should ensure that assigned tasks and any boundaries of the work scope are clearly understood by all workers.

KEYWORDS: *Work control, accountability, evacuation, chemical odor, unauthorized work, venting*

ISM CORE FUNCTIONS: *Define the Scope of Work, Perform Work within Controls*

4. NUMEROUS UNEXPECTED ELECTRICAL LINE INTRUSIONS

There have been a number of incidents in recent months in which energized electrical cables in conduits were penetrated or severed during construction, modification, or demolition activities at DOE facilities. No serious injuries resulted from these unanticipated intrusions on electrical lines, and they were categorized as near-misses. The frequency of these incidents has averaged approximately two per month for the past two years, and five events occurred in the 11-day period September 29 through October 9, 2001. A general characterization of the events is that the workers were either unaware that the energized cables were in the path of their work, or they were aware that a nearby conduit existed, but breached it inadvertently. Work plans for the activities resulting in these preventable events were either not followed or deficient. Figure 1 shows a typical assemblage of wires, cables, conduits, and piping being installed in a wall during construction, before concealment.

The purpose of this article is to notify the DOE complex of the characteristics of these continuing electrical intrusion events, and their frequency, with the intent of helping workers avoid such events in the future. A more detailed and comprehensive report on electrical intrusion events, examining more than 50 occurrences over a two-year period, is in preparation.

Figure 1. Wires, cables, conduits, and piping being installed in a wall

This summary article describes the events documented in 16 occurrence reports for unanticipated electrical intrusion incidents that occurred during a 15-week period bounded by July 10 and October 24, 2001. The following paragraphs describe the types of occurrences, the results of the causal analyses from finalized occurrence reports, some lessons learned that can be drawn from the causal analyses and related corrective actions, and some conclusions.

Characterization of Events

The 16 occurrence reports were categorized by engineers in the EH Office of Performance Assessment and Analysis as either "dig" events (5 reports) or "drill/cut" events (11 reports). The occurrence report numbers and dates for the events examined are presented in Table 1.

Table 1. List of Electrical Intrusion Occurrence Reports

DIG OCCURRENCES	DRILL/CUT OCCURRENCES
CH-AA-ANLW-ANLW-2001-0002 * (25 July 2001)	OAK--LLNL-LLNL-2001-0024 * (10 July 2001)
RL--PNNL-PNNLBOPER-2001-0011 * (07 August 2001)	RFO--KHLL-WSTMGTOPS-2001-0030 * (13 July 2001)
ORO--BJC-Y12WASTE-2001-0009 (18 September 2001)	ORO--BNFL-K31-2001-0003 * (23 July 2001)
ORO--ORNL-X10SNS-2001-0001 (21 September 2001)	ORO--BNFL-K33-2001-0011 (20 August 2001)
CH-AA-ANLE-ANLEPFS-2001-0019 (04 October 2001)	ORO--BNFL-K33-2001-0018 * (10 September 2001)
	ALO-LA-LANL-CMR-2001-0029 (29 September 2001)
	ALO--MCTC-GJPOTAR-2001-0003 (01 October 2001)
	ID--BBWI-CFA-2001-0014 (03 October 2001)
	ALO--MCTC-GJPOTAR-2001-0004 (09 October 2001)
	ALO-KO-SNL-NMFAC-2001-0008 (13 October 2001)
	ALO-KO-SNL-NMFAC-2001-0009 (24 October 2001)

* Final occurrence report available

The “dig” occurrence reports involved subcontractors who used backhoes, augers, and a trenching machine. In two of these events, subcontractors violated procedures that required hand-digging within five feet of known utility lines or enclosures. These events affected energized lines of 110, 120, 220, and 240 volts. The majority of the “drill/cut” events involved workers for the prime contractors who were using hand power tools. These occurrences affected energized lines of 110, 120, 208, and 480 volts. The “drill/cut” events covered a wide range of activities; for example, removing electrical conduit as part of a demolition task, dismantling a radiological hood, installing a bookshelf, drilling through the outside wall of a building, installing roofing panels, and dismantling electrical equipment.

Results of Causal Analyses

Several of the 16 occurrence reports examined presented the results of causal analyses in terms of direct causes, contributing causes, and root causes for the incidents. The direct cause for all except one of these analyzed events was some form of personnel error; e.g., inattention to detail, or procedure not used or used incorrectly. For the other event, the direct cause was identified as a problem with the design drawing, which showed the conduit but failed to identify its correct location.

The predominant contributing causes for these events were management problems of various types, such as work organization/planning deficiency or policy not adequately defined, disseminated, or enforced. Personnel errors also were cited as contributing causes; e.g., procedure not used or used incorrectly, inattention to detail, or communication problems. Training and procedural deficiencies were also presented as contributing causes.

Personnel errors were the dominant root causes cited in the reports; e.g., inattention to detail and procedures not used or used incorrectly. The second largest category of cited root causes was management problems; e.g., work organization/planning deficiencies. Also listed as root causes were problems with design drawings and defective or inadequate procedures.

Lessons Learned

The lessons learned cited in the six final occurrence reports were generally narrow in scope and tightly focused on the events that were being addressed. However, some broadly applicable lessons learned were derived from the causal analysis results, the related corrective actions, and the reported event-specific lessons learned, as presented below.

Complacency should be avoided in the workplace. In the report on one of the events, workers stated that they had cut hundreds of conduit without incident. Individual workers need to take ownership of their own safety, pay attention to what they are doing, and maintain an inquiring attitude that focuses on the task at hand, even if they have performed the task many times before. Part of the concept of personal ownership of safety is the ability and willingness to exercise stop-work authority.

The importance of complying with safety requirements and work procedures needs to be continuously emphasized in management directives and training programs. The requirements and procedures were established to protect workers, and taking shortcuts negates the protection they would otherwise provide. In two of the events, workers decided to ignore procedures that required hand digging near buried utilities. In one of these, workers decided to save time and effort by using a backhoe, and in the other event workers believed that they could decide on their own if hand-digging was necessary.

Managers need to ensure that the appropriate mix of skills and experience needed for performance of a specific task is, in fact, assigned to the task and is present when the work is being performed. Some of the electrical intrusion incidents involved inexperienced or unqualified workers attempting to perform work on or near electrical systems.

Work crews performing work in remote locations need to have access to instant two-way communications in order to receive appropriate direction when problems are encountered and to seek timely assistance in responding to incidents.

Supervisors and workers need to review digging permits and electrical work permits at the job site so that potential hazards are understood. In some cases, workers failed to comply with permit requirements for marking energized electrical lines, checking for voltage, and inadequate equipment labeling.

Supervisors need to ensure that workers use personal protective equipment that is appropriate for electrical hazards if there is a potential for inadvertently encountering energized electrical lines.

Supervisors and workers need to use the best available technologies in scanning equipment (e.g., Ferroscan and Ground Penetrating Radar). However, users need to recognize that scanning equipment has limitations that require personnel to continue to exercise caution in excavation and drilling/cutting activities.

Violations of safety requirements or agreed-to work procedures need to be addressed swiftly and fairly. Formal violation notices, with appropriate disciplinary actions, should be imposed on personnel involved.

Conclusions

These electrical intrusion events underscore the importance of using effective work control practices and detailed pre-job planning processes for construction, modification, and demolition activities. The responsibility for ensuring adequate planning and control of work activities resides with line management. Managers need to ensure that work control processes are followed and that facility safety requirements are enforced. A safety and health hazard analysis should be included in the work planning process to help prevent worker injuries, and should include provisions for drawing reviews, job-specific walkdowns, personal protective equipment, and the use of equipment to detect embedded conduit. Pre-job briefings, facility procedures, and training programs should emphasize the electrical safety hazards associated with penetration activities.

References

The documents listed below provide useful information on avoiding or mitigating the consequences of unanticipated intrusions into energized electrical lines.

- Lessons Learned Report 98-02, *Penetrating Hidden Utilities*, available on the Internet at http://tis.eh.doe.gov/oeaf/ll.html.
- 29 CFR 1926.416(a)(3), *Protection of Employees*
- DOE/EH-0557, Safety Notice 98-01, *Electrical Safety*

KEYWORDS: *Electrical safety, work controls, damaged conduit, construction safety*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work Within Controls*

5. LIFTING SLING FAILS BECAUSE OF INADEQUATE CHAFING PROTECTION

On August 29, 2001 at the Brookhaven National Laboratory, one end of a Large Hadron Collider magnet fell approximately 4½ feet to a concrete floor when one of two lifting slings failed. No one was injured and the damage to the 11,000-pound magnet was not severe. Personnel secured the area for investigation and locked out the crane pending an inspection by the Laboratory crane inspector. Investigators determined that riggers used material that did not provide adequate chafing protection, which allowed a sharp corner of the magnet support casting to cut through the sling. A final report was recently filed that provides some insight into sling protection when lifting heavy loads. (ORPS Report CH-BH-BNL-BNL-2001-0023)

Figure 1. The magnet in its lifting slings

Riggers used a building bridge crane and two nylon composite slings, as shown in Figure 1, to lift the magnet while it was being transferred between assembly stations. The slings were purchased specifically for the program, and each was rated for a load of 21,200 pounds. The load angle for the lift was between 25 and 30 degrees, resulting in approximately 13,000 pounds of tension in each sling. The slings were rigged so that they pressed against the corners of the magnet support castings. The riggers recognized these corners as chafe points and installed anti-chafing protection that consisted of three pieces of cut-up fire hose and a piece of folded and taped polystyrene. Figure 2 shows one of the slings with a piece of fire hose being utilized as chafing protection.

Three technicians started to install three sets of plates on the bottom of the magnet assembly, while the magnet was suspended. The sling on the east side of the magnet failed at this time (Figure 3), dropping that end of the magnet to the concrete floor and forcing the crane westward, which allowed the other end of the magnet to land on the floor. The sling failure could have resulted in a catastrophic accident because personnel were working under or near the load when it fell. A serious injury could have resulted. Investigators determined that the damage to the magnet was repairable.

Figure 2. One of the lifting slings with the piece of fire hose to protect against chafing

The direct cause of the event was the use of inadequate anti-chafing material that failed to protect one of the two slings from being cut by the support casting of the magnet. The three chafe points that used sections of fire hose did not experience damage to the sling at these points. The fourth chafe point that used folded and taped polystyrene packing material was cut through at the location where the sling failed. The sling requirements for rigging the magnet were properly evaluated. However, the chafing potential was underestimated. This incident could have been prevented if the work plan had properly evaluated the lift and identified adequate anti-chafing material. In addition, a straight pick, using a lifting bar fixture, could have been recommended that would have eliminated the need for a sling and anti-chafing material altogether.

Another issue was that personnel did not follow the magnet assembly procedure that required the magnet to be moved to an inspection table and supported before the step that required personnel to install parts under the magnet (i.e., the parts being installed when the sling failed).

Although personnel had the required crane training and recognized the need for anti-chafing material, current training does not identify which materials were acceptable (or unacceptable) for protecting lifting slings. The production supervisor, who performed the rigging evaluations/calculations, had attended an advanced rigging training course intended to increase the knowledge, skills, and abilities of personnel who make rigging evaluations/calculations. This course discussed the need for chafing protection, but did not specifically address material selection.

Figure 3. The failed sling

The following corrective actions will be implemented.

- Develop a divisional procedure that uses anti-chafing materials that are either commercially approved or have been evaluated by engineering as acceptable.
- Revise the Laboratory Basic Rigging Course to address material selection for chafing protection.
- Conduct a review of divisional procedures and practices and implement changes to prohibit personnel from working under suspended loads.
- Revise assembly procedures for the Large Hadron Collider magnet to use a spreader bar for lifting, to eliminate the need for slings and chafing protection.

Lessons learned from this event include the following:

Hoisting and rigging issues need to be addressed as part of the work planning process. The work plan should eliminate, if possible, or minimize the need for chafing protection. Commercially available chafe guards or guards approved by engineering should be used if a chafe guard is required between a sling and an item being lifted. Whenever chafe guards are used, the item should be lifted to a minimal height to ensure that the full load has been applied, then lowered to verify guards are providing the proper protection. The load can then be lifted, provided that no damage was noticed to any of the lifting components. If damaged, further evaluation is required. Personnel should never work under a suspended load. The load should be lowered onto structural supports capable of bearing the full weight of the item before anyone works under a load.

Guidance for proper use and maintenance of lifting slings can be found in DOE-STD-1090-2001, *Hoisting and Rigging*. Chapter 11, Wire Ropes and Slings, provides specific guidance for protecting slings from damage caused by sharp edges. It also identifies some anti-chafing materials, such as corner saddles, burlap padding, wood blocks, and leather pads.

The Occupational Safety and Health Administration (OSHA) Office of Training and Education publication *Sling Safety* states that proper care and usage of slings are essential for maximum service and safety. Slings must be protected from sharp bends and cutting edges by means of cover saddles, burlap padding, or wood blocking, as well as from unsafe lifting procedures such as overloading. OSHA Standard 29 CFR 1910.184, *Slings*, states that slings shall be padded or protected from the sharp edges of their loads. This standard also includes information on sling usage, maintenance, and sling capacity tables. OSHA regulations and standards can be accessed at http://www.osha.gov/comp-links.html.

KEYWORDS: *Hoisting/rigging, lifting sling, chafe point*

ISM CORE FUNCTIONS: *Analyze the Hazards, Develop and Implement Hazard Controls*